(12) UK Patent Application (19) GB (11) 2 136 033 A

(43) Application published 12 Sep 1984

(21) Application No 8331109

(22) Date of filing 22 Nov 1983

(30) Priority data

(31) 8305537 (32) 28 Feb 1983 (33) GB

(51) INT CL³
E04B 2/86

(52) Domestic classification
E1D 2050 2160 402 450 547 904 LEJK
U1S 1754 E1D

(56) Documents cited
GB 1538734 GB 1413330
GB 1412613 GB 1086311
GB 0546105

(58) Field of search
E1D
E1W

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# (54) Off-shore structures

(57) An off-shore structure has inner and outer steel skins (8 and 10) linked by steel webs (12), and filled with cementitious material (16). The skins are built-up from individual steel plates welded to the webs (12) and to each other so as to provide an impervious covering for the cementitious material. The spacing between the webs is less than four times the spacing between the skins to ensure that the plates do not lose integrity with the concrete when the structure is under loads.

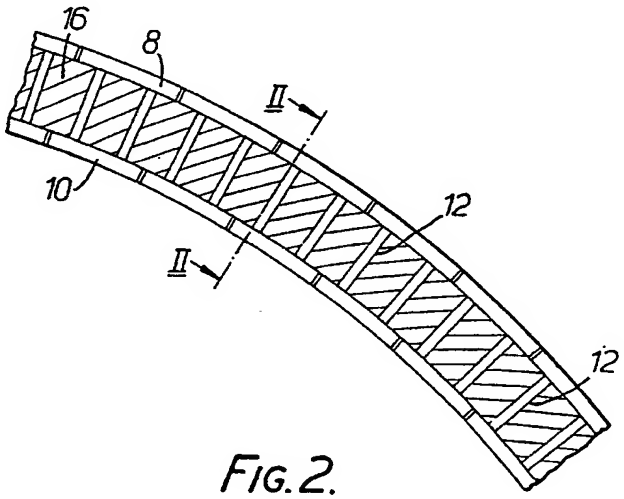


FIG. 2.

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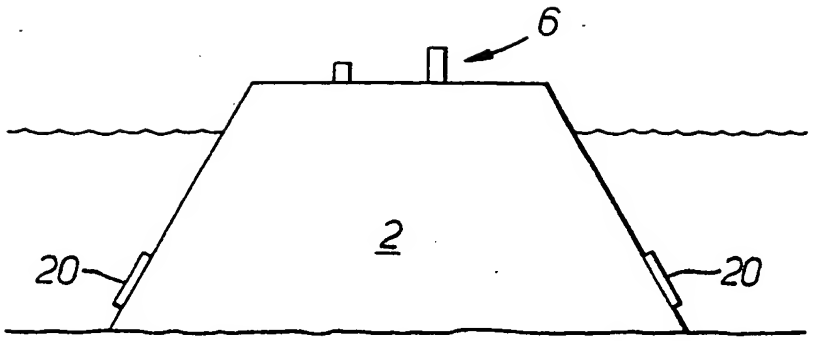


FIG. 1.

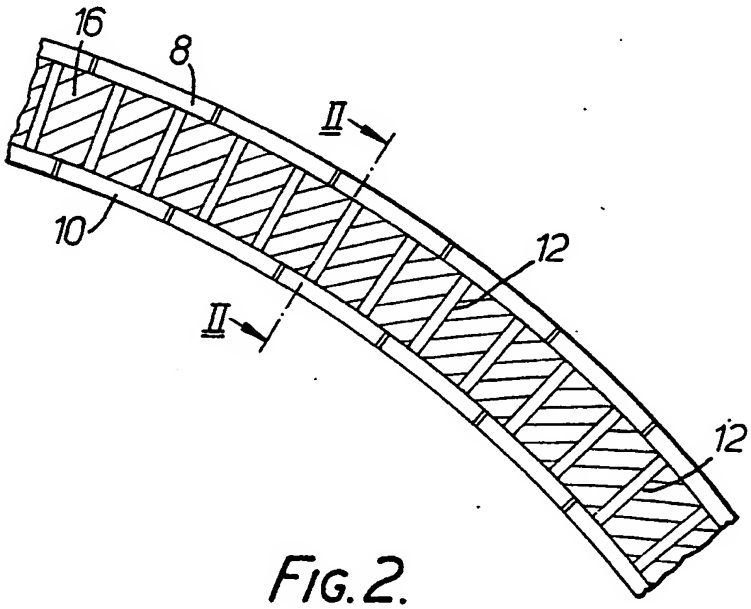


FIG. 2.

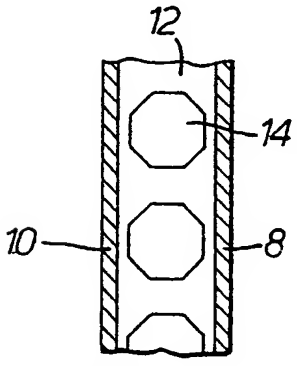


FIG. 3.

SPECIFICATION

**Reinforced structures**

The present invention relates to structures for example of steel and concrete.

Underwater exploration for minerals such as oil often requires structures mounted on the seabed to extend above the surface of the sea, so as to provide a stable working environment.

Such structures can be made of reinforced concrete to withstand the elements of sea and wind. In circumstances where the structure is subject to such additional hazards as ice pressure and ship impact, the structures need to be extensively reinforced and this involves not only high expense but also long construction times.

According to the invention, there is provided a structure comprising a pair of spaced apart steel skins, an array of steel members inter-connecting the two skins, the spacing between the individual members of the array being less than four times the spacing between the skins, and a cementitious infill between the two skins.

According to the invention, there is further provided a reinforced concrete structure in which the reinforcing material is arranged to define an array column-like intercommunicating compartments enclosing cementitious material, and is also arranged to form the inner and outer skins of the structure, the dimensions of each column in a direction parallel to the planes of the skins being less than four times its dimension in a direction at right angles of two skins.

According to the invention, there is still further provided a structure comprising an array of steel members extending between two spaced parallel planes, with the spacing between adjacent members of the array being less than four times the spacing between the two planes, a first plurality of steel panels secured to the array and secured to one another to form a skin on one side of the array extending in one of said planes, a second plurality of steel panels secured to the array and to one another to form a skin on the opposite side of the array extending in the other of said planes and concrete filling or partially filling the space between the two skins.

A structure embodying the present invention will now be described by way of example, with reference to the accompanying diagrammatic drawings, in which:

Figure 1 is a perspective view of the structure;

Figure 2 is a fragmentary horizontal section through the structure of Figure 1; and

Figure 3 is a section taken on the line II—II of Figure 2.

As shown in Figure 1, a structure 2 located on the seabed 4 has an upper working station 6 located above the surface of the sea.

The structure has a sloping outer surface to facilitate the breaking up of sheet ice coming into contact with the structure.

As shown in Figure 2, the structure is composed of a series of outer steel plates 8 and inner steel plates 10 respectively defining the outer and inner skins of the structure. The inner and outer plates 8 and 10 are held in place by a series of steel webs or strips 12 located between the plates and extending at right angles to the plates. Each strip 12 as shown in Figure 2 is provided with a series of hexagonal openings 14.

The spacing between adjacent strips 12 is preferably equal to the spacing between the inner and outer plates 8 and 10. The spacing can be as great as up to four times the spacing between the plates 8 and 10, but is advantageously less than twice the spacing between the plates 8 and 10.

The space between the inner and outer skins is filled with a cementitious material 16.

The strips 12 are designed to resist any tensile forces set up within the concrete due to localised loading such as produced by a sheet ice or a ship impact.

The strips 12 are designed to ensure that the inner and outer plates 8 and 10 are held together while cementitious material in the form of concrete is cast between them. The strips 12 also act to ensure that the inner and outer plates do not lose integrity with the concrete when the structure is under load since the strips act to resist the plates 8 and 10 pulling away from the concrete as well as opposing shear between the concrete and the plates 8 and 10.

The building of the structure is advantageously performed by welding together a series of arcuate elements. Each element, which may be factory produced, is in the form of a series of spaced strips with plates welded to the strips on both sides. Adjacent plates are welded together to form an unbroken skin. The elements are then transported to the site and fitted side by side to the shape of the structure; adjacent elements being welded together. A cementitious material is then poured into the space between the two skins which act as the shuttering for the material. Because the strips 12 are provided with openings 14, the material is keyed into the structure.

Because the inner and outer skins are continuous, they form an impermeable membrane and so present exposure of the cementitious material between the skins to water or moisture. The cementitious material is preferably an air entrained concrete containing a light-weight aggregate to provide good resistance to freeze-thaw conditions.

Cathodic protection 20 provided on the outer surface of the structure acts to inhibit corrosion.

Advantageously, the outer skin is coated with a low friction material to facilitate sheet ice sliding up the side of the structure as it comes into contact with the structure and so easing the rupture of the sheet ice.

It will be appreciated that since both the inner and outer steel skins are continuous, they provide a more efficient resistance to punching or impact. The arrangement of the plates and strips to provide column-like compartments and the column-like filling of cementitious material within the compartments, together act to provide the structure with high resistance to punching,

whether it be from ice or ships.

The net result is that the structure will require less steel than a conventional reinforced structure providing the same punching resistance.

The provision of inner and outer skins will avoid the use of shuttering during the construction of the structure since the skins themselves will act as permanent shuttering. This avoids the use of temporary shuttering and associated temporary works and so provides a savings in costs. Internal reinforcements may be omitted or minimised and reinforcement steel fixings will not be needed.

While the whole structure is covered with steel sheet plates, it will be appreicated that only the section of the structure in the vicinity of the water line, where sheet ice is likely to come into contact, need be so constructed. The remainder of the structure may be of conventional construction.

It will also be appreciated that the structure may be used in other applications and can take the other forms, such as cylindrical or laminar.

When the structure has suffered punching damage, steel plates can be welded to the outer surface to cover the damaged area and the space behind the plates injected with resin or grout or be filled with cementitious material. No need for temporary shuttering arises.

Advantageously, steel plate-like elements (not shown) extending at right angles to the skins are welded to the inner surface of the skins in a manner so as to resist shear displacement of the concrete in directions extending parallel to the strips 12.

CLAIMS

1. A structure comprising a pair of spaced apart steel skins, an array of steel members interconnecting the two skins, the spacing between the individual members of the array being less than four times the spacing between the skins, and a cementitious infill between the two skins.

2. A reinforced concrete structure in which the reinforcing material is arranged to define an array column-like interconnecting compartments enclosing cementitious material, and is also arranged to form the inner and outer skins of the structure, the dimensions of each column in a direction parallel to the plans of the skins being less than four times its dimension in a direction at right angles to the planes of two skins.

3. A structure, according to Claim 2, wherein the reinforcing material is in the form of an array of steel members and a plurality of steel panels secured to the members to cover two opposite sides of the array.

4. A structure comprising an array of steel members extending between two spaced parallel planes, with the spacing between adjacent members of the array being less than four times the spacing between the two planes, a first plurality of steel panels secured to the array and secured to one another to form a skin on one side of the array extending in one of said planes, and a second plurality of steel panels secured to the array and to one another to form a skin on the opposite side of the array extending in the other side of said planes, and concrete filling or partially filling the space between the two skins.

5. A structure according to Claim 3 or Claim 4, wherein the array is fustro-conical to form a fustroconical structure.

6. A structure according to any one of Claims 3 to 5, wherein the steel panels are secured to each other and the array by welding.

7. A structure according to any preceding Claim, wherein the outer surface of at least one skin is covered with a protective coating.

8. A structure according to any preceding Claim, wherein at least one skin is provided with cathodic protection.

9. A structure according to any preceding Claim, wherein each steel member is in the form of a strip or web provided with a plurality of openings to enable the concrete infill to be keyed into the structure.

10. A structure, substantially as hereinbefore described, with reference to the accompanying drawings.

Printed in the United Kingdom for Her Majesty's Stationery Office, Demand No. 8818935, 9/1984. Contractor's Code No. 6378.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.